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APPLICATION NUMBER: *60/432,467*
FILING DATE: *December 10, 2002*
RELATED PCT APPLICATION NUMBER: *PCT/US03/39309*

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No. EV 041931624 US

INVENTOR(S)		
Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Steven	Constable	San Diego, California

☐ *Additional inventors are being named on the _____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

Hydrocarbon reservoir monitoring using marine controlled source electromagnetic fields

CORRESPONDENCE ADDRESS

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PATENT TRADEMARK OFFICE

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 4 ☐ CD(s), Number

☒ Drawing(s) *Number of Sheets* 2 ☐ Other (specify)

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☒ Applicant claims small entity status. See 37 CFR 1.27.

☒ A check or money order is enclosed to cover the filing fees

FILING FEE AMOUNT ($) 80

☐ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number:

☐ Payment by credit card. Form PTO-2038 is attached.

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: _____.

Respectfully submitted,

SIGNATURE Eleanor M Musick

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Date 12-10-02

REGISTRATION NO. *(if appropriate)* 35,623

Docket Number: PR3083 (51293/281172)

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1 51 The information is used by the public to file (and by the PTO to process) a provisional application Confidentiality is governed by 35 U S C 122 and 37 CFR 1 14 This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO Time will vary depending upon the individual case Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U S Patent and Trademark Office, U S Department of Commerce, Washington, D C , 20231 DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS SEND TO Box Provisional Application, Assistant Commissioner for Patents, Washington, D C 20231

12/10/02 JC893 U.S. PTO
J1036 U.S. PTO 60/432467

HYDROCARBON RESERVOIR MONITORING USING MARINE CONTROLLED-SOURCE ELECTROMAGNETIC FIELDS

Background of the Invention

It is important to monitor changes in hydrocarbon reservoirs during gas/oil extraction. Existing art involves the drilling of monitoring wells, or sensors placed in the extraction well. Other existing methods include repeat seismic surveys. The seismic method measures acoustic properties, which are less well correlated with actual hydrocarbon content than is electrical resistivity. Also, continuous seismic surveying is impractical. Borehole seismic surveying involves expensive well down-time.

Summary of the Invention

The present invention provides for the continuous mapping of reservoir structure over a large area without the use of expensive wells. A more comprehensive image of reservoir geometry is then possible compared to the image that can be generated by using only a small number of discrete monitoring wells.

According to the present invention, time changes in the electrical resistivity of seafloor reservoirs can be monitored using electromagnetic methods. Changes in reservoir resistivity occur when oil and gas are replaced by water. Both the thickness and lateral extent of the reservoir can be monitored by this invention. Such monitoring allows well positions and extraction rates to be optimized for total extraction over the life of the reservoir.

In an exemplary embodiment, cables connected to receiver electrodes (such as, but not limited to, silver-silver chloride electrodes) are laid out on the seafloor around a hydrocarbon production platform, extending over the area of the hydrocarbon reservoir. Electric fields across these electrodes resulting from EM transmissions are monitored on the production platform. Amplification can be applied in sub-sea amplifiers or on the platform. Transmission antennas are installed separately. Electric currents are applied sequentially between pairs of transmitting electrodes, which are arranged to produce vertical, radial and azimuthal electric fields, respectively. Transmission frequencies are determined by the depth of the reservoir and the electrical conductivity of overlying sediments, and are typically 0.25 Hz for 1 km deep reservoirs.

Transmission electrodes can be laid horizontally on the seafloor or hung vertically from the platform. It is preferable that vertical transmissions are made.

The size and position of the electric fields at the transmission frequencies determines the extent and thickness of the reservoir. The radial electric field mode is most sensitive to the reservoir. By installing transmitter and receiver electrodes permanently on the seafloor, variations in the size of the received EM signals depend only on changes in the reservoir, and not on relative proximity of other geology that would occur if the electrodes were moved. However, repeat surveys using seafloor data loggers and ship-towed transmitters could be carried out.

The present invention provides a system for real-time monitoring of a hydrocarbon reservoir and its features on the ocean bottom. The system includes an electromagnetic source assembly for transmitting a first plurality of electromagnetic fields; a seafloor cable electrode array adapted for receiving a second plurality of electromagnetic fields and generating signals therefrom; a data logging processor for receiving the signals over time and storing data corresponding to the signals; a clocking device for providing a timing signal to the processor for synchronization; and a power supply for providing power to each of the electromagnetic source, the seafloor cable electrode array, the processor and the clocking device, wherein the second plurality of electromagnetic fields correspond to the first plurality of electromagnetic fields subjected to a reservoir resistivity. The electromagnetic source assembly include at least a vertical field transmitter.

The invention further provides a method for monitoring a hydrocarbon reservoir at the floor of an ocean or other body of water which includes deploying from a platform on the body of water, an assembly comprising an electromagnetic field transmitter, a plurality of receiver electrodes distributed around the electromagnetic field transmitter for detecting the electromagnetic field, at least one processor for receiving and logging data corresponding to signals generated by detection of the electromagnetic field, a clocking device for synchronizing the data logging; and analyzing logged data for real-time monitoring of electromagnetic parameters on the floor of the ocean or other body of water, wherein the electromagnetic parameters correspond to changes in reservoir resistivity for determination of lateral extent and depth of the reservoir. Multiple processors may be used and the data combined for

measurement over large areas. The clocking device is further used to synchronize between the multiple processors. The method for monitoring a hydrocarbon reservoir may be used during extraction and production to evaluate rate of extraction.

Brief Description of the Drawings

Figure 1 is a side view of a system according to the present invention, where transmission electrode pair A + B produces a vertical field that is measured on all receiver electrodes.

Figure 2 is a top plan view of the system according to the present invention, where transmission electrode pair C + D produces a radial field which is measured on receiver electrodes a, b, c, and d, and transmission electrode pair E + F produces an azimuthal field the is measured on receiver electrodes e and f.

References (Incorporated herein by reference.)

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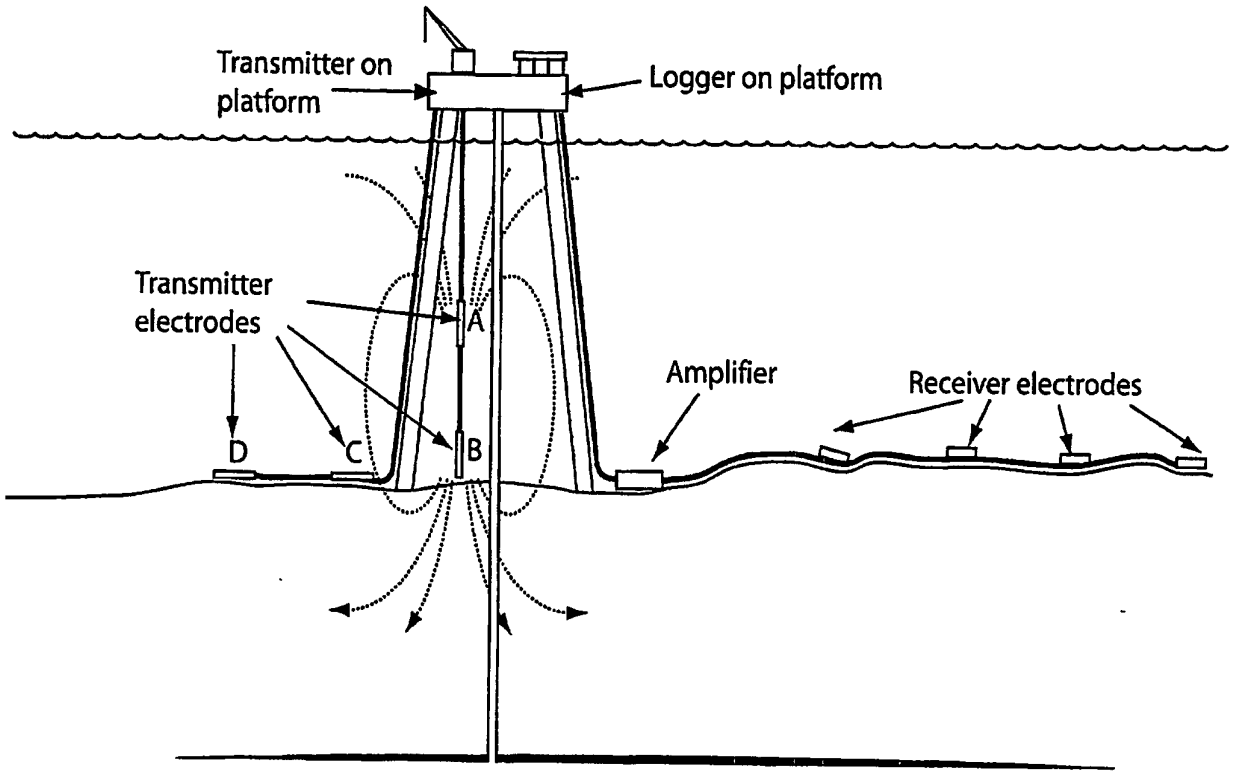
Figure 1


Transmitter on platform
Logger on platform
Transmitter electrodes
A
B
C
D
Amplifier
Receiver electrodes

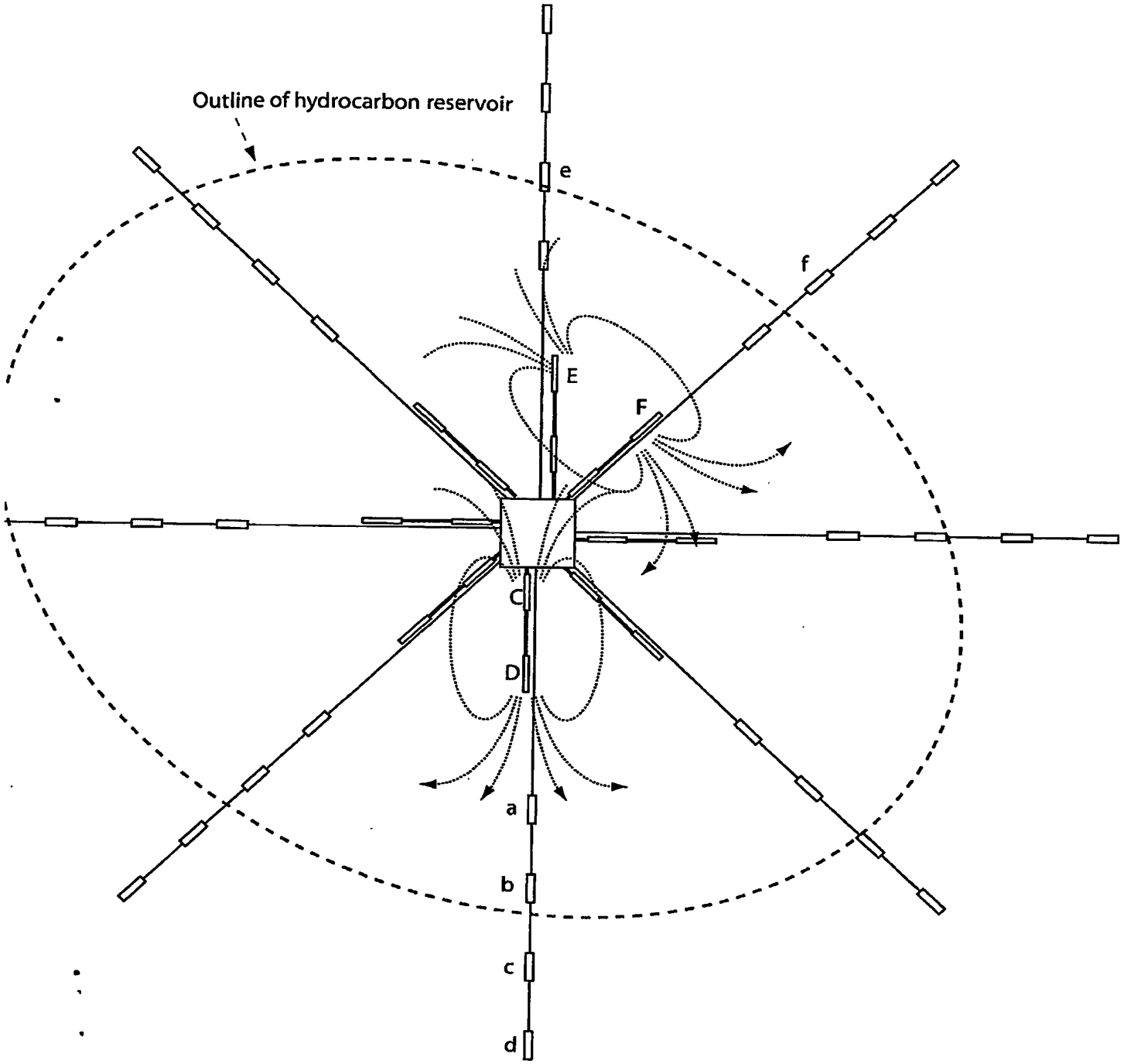


Figure 2

Energize transmitter electrodes C and D to create radial fields measured on receiver electrodes a, b, c, d.
Energize transmitter electrodes E and F to create azimuthal fields measured on receiver electrodes e and f.